Preliminary Shell Model Calculations for Corresponding Homologous States in ^{42}Ca and ^{41}K Nuclei

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During the last years, with the advent of very powerful experimental devices and techniques together with new developments from the theoretical side, a renewed interest has been devoted to the study of the spectroscopy of medium-light nuclei. In particular, special attention has been devoted to $f_{7/2}$-shell nuclei where a wide variety of interesting phenomena has been put in evidence. The key issues in these studies have been the test of the shell model effective interactions, their capability in describing collective motion (e.g. rotational motion) and to compare, in a unique physical system, both the shell model and mean field methods [1,2,3].

It has been shown that the structure of these nuclei strongly depends on the competition of the different fp orbitals for the natural parity states and on the contribution of other major shells in the unnatural parity states. This has put in evidence the present lack of effective interactions able to take into account more than one major shell. New effective interactions for the $sd + fp$ shells have been recently introduced. They are still under development and new data which directly provide specific matrix elements are required [4,5].

Experimentally these studies have been done mainly in fusion-evaporation reactions induced by heavy ions but the information has to be complemented with the outcome from transfer reactions, which are essential to better specify the nature of the different states. Of particular interest is the possible occurrence of 'similar' states in neighbouring systems which could imply the persistence of preferred structures that survive after the addition of one or more particles that, in these cases, behave as spectators. An example of such phenomena could be the presence of homologous states in ^{42}Ca and ^{41}K that could be populated in the ^{45}Sc(p,α)^{42}Ca and ^{44}Ca(p,α)^{41}K reactions, respectively.

Exploratory shell model calculations, involving one hole excitation from the $d_{3/2}$ shell to the full fp shell, have been performed and seem to reproduce some of the features of recent experimental findings in these reactions [6]. Calculations have been done with the code ANTOINE [7] and the interaction *sdfp.sm* [8] for both ^{41}K and ^{42}Ca. In the case of ^{41}K, the dominant configuration ($\sim 90\%$ probability) of the $3/2^+$ ground state is $\pi({d_{3/2}}^{-1})\ \nu({f_{7/2}}^2)$. For ^{42}Ca we have calculated the low spin negative parity states $J^\pi = 2^-, 3^-, 4^-$ and 5^-. The relative excitation energies of the 3^-, $4^-$and 5^- states are in good agreement with the data. The dominant configuration ($\sim 70 - 75\%$) of these states is $\pi({f_{7/2}}^1 {d_{3/2}}^{-1})\ \nu({f_{7/2}}^2)$, as would be expected in the hypothesis of homologous states. The 2^- state, however, has a very different structure. In fact, several configurations contribute to the state wave function. This is in agreement with the fact that this state seems not to be populated in the ^{45}Sc(p,α)^{42}Ca reaction [6], as shown in the reported figure.

References

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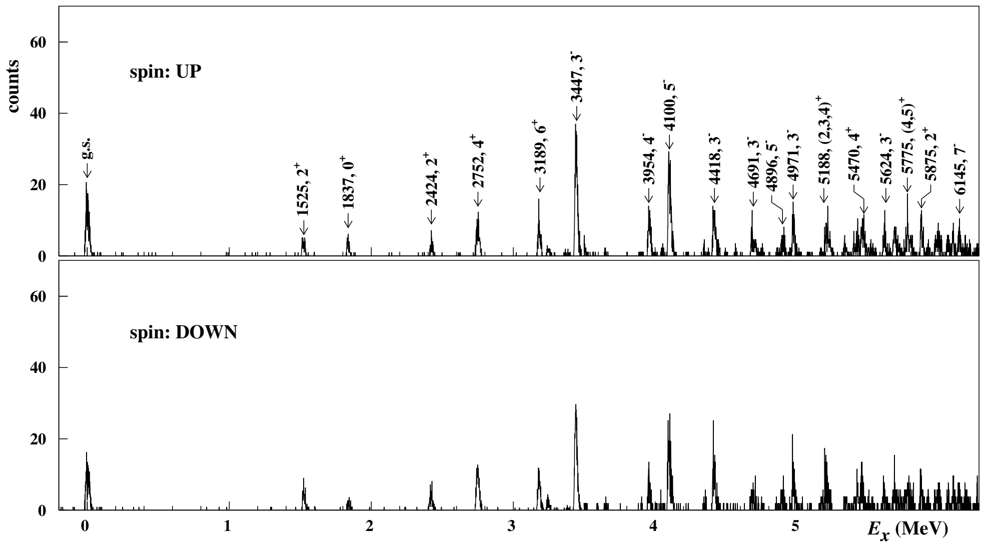

Fig. 1: α-spectrum for the ^{45}Sc($\vec{p}$,α)^{42}Ca reaction. Numbers: ^{42}Ca level energies in keV, spin and parity.